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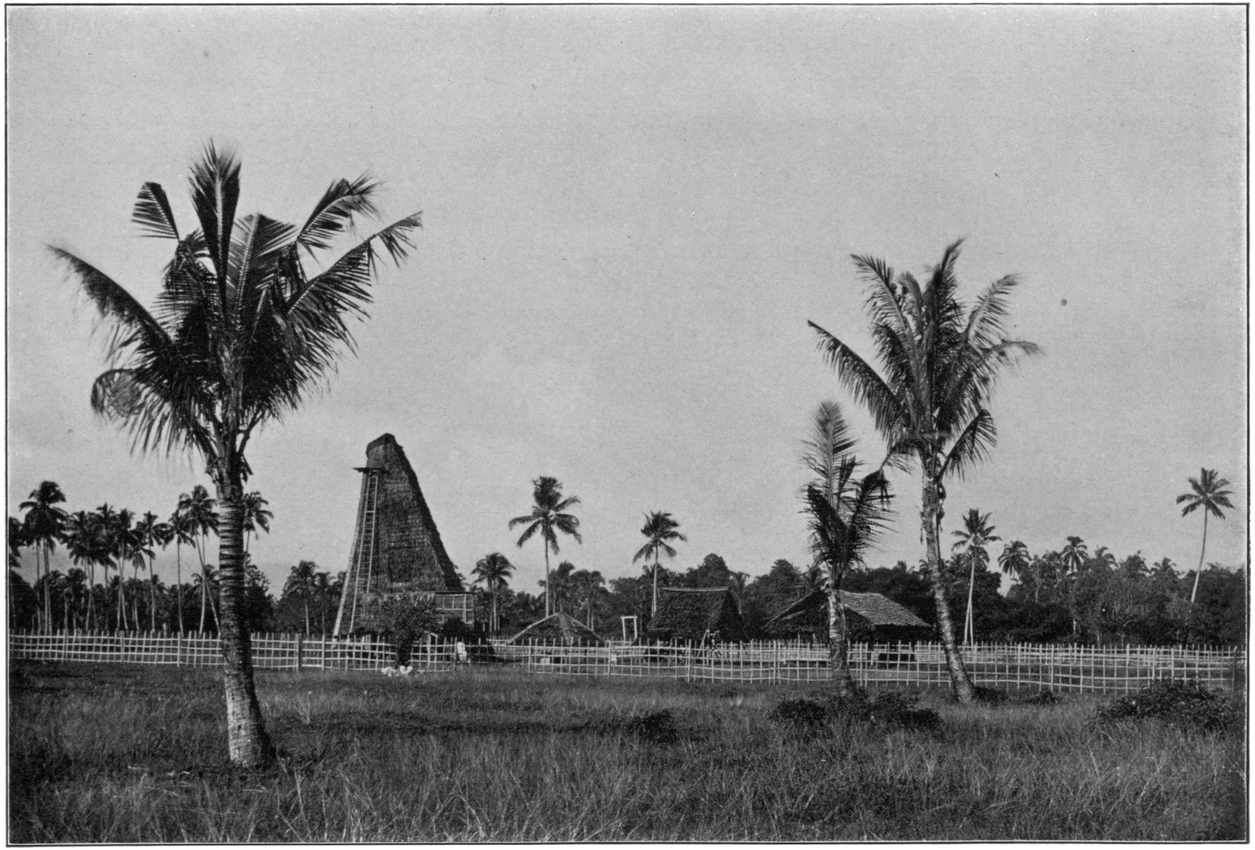

LICK OBSERVATORY – CROCKER ECLIPSE STATION, PADANG, SUMATRA.

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THE LICK OBSERVATORY–CROCKER EXPEDITION TO OBSERVE THE TOTAL SOLAR ECLIPSE OF 1901, MAY 17–18.

By C. D. PERRINE.

In continuation of the expeditions dispatched by the Lick Observatory for the observation of total solar eclipses, one was sent to Sumatra to observe the eclipse of May 17–18, 1901. These expeditions have been made possible by the generosity of private citizens of California who have borne the expenses incident to such undertakings. Inaugurated by Colonel CHARLES F. CROCKER, Regent of the University of California and member of the Committee on the Lick Observatory, they have been continued since his death by his brother, Mr. WILLIAM H. CROCKER, of San Francisco.

Owing to the temporary difficulty of forming future plans after the death of Director KEELER, the organization of the expedition was delayed and the preparations were hurried. While some of the observations planned for were the same as those undertaken at former eclipses, and for which the apparatus needed but slight changes to adapt it to the present eclipse, several investigations required the construction of entirely new instruments. The four telescopes for the intramercurial planet search, two spectrographs, and a polarigraph were constructed and tested in less than a month. The entire staff of the Observatory took up the work, so that, notwithstanding the stormy and unfavorable weather, the equipment was packed and ready for shipment in time for the steamer leaving San Francisco on February 19th for Hongkong.

A rather large equipment of instruments was taken, as previous experience had shown the feasibility of obtaining observers to operate them at or near the station.

The expedition left San Francisco on February 19th, on the steamship "Nippon Maru," of the Toyo Kisen Kaisha. At Honolulu we found the United States transport "Sheridan," and there exchanged greetings with the members of the United States Naval Observatory party.

It was hoped that connection could be made with the North-German Lloyd steamer leaving Hongkong on March 20th for Singapore, but owing to almost continuous heavy weather and head winds as far as Yokohama, we were two days late at the latter port, and reached Hongkong only in time to see the coveted steamer leaving the dock.

Fortunately, however, the "China," a steamer of the Austrian Lloyd Steamship Company, was found to be leaving in two days. After a good run of five days, Singapore was reached on March 27th. The steamer of the Koninklijke Paketvaart-Maatschappij left on the 29th for Batavia. Although having a full cargo of freight and a heavy passenger-list, the agents made room for us, placing the instruments in the second-class cabins. Batavia was reached on March 31st. The through steamer for Europe of the Stoomvaart-Maatschappij Nederland was leaving Batavia on April 3d, stopping at Padang for through passengers and freight only. Again the steamship company was most accommodating, giving us passage on a crowded steamer, and placing the eclipse freight in the baggage-room. Thus we arrived in Emmahaven on April 5th, at daylight, fully ten days earlier than was expected when we left California. Almost the first sight to greet our eyes in the harbor at Emmahaven was the United States steamer "General Alava," with the astronomers of the United States Naval Observatory party on board, they having arrived from Manila the evening before.

From Hongkong to Padang it was noticed that often when the sky near the zenith was fairly clear of clouds they seemed to hover about the land, particularly the mountains, and rain was often seen to fall there. Observations at Padang for several days after arrival showed that the clouds gathered about the mountain-tops and spread thence towards the plains and the ocean. The early mornings were often quite clear, but almost invariably clouds began to gather over the mountains by nine or ten o'clock, and rain was of frequent occurrence in the afternoons. The location, therefore, which seemed to promise best was one as far as possible from any high mountains. Padang is situated in the southern end of a long plain, three or four miles wide, bounded on the west by the ocean, on the south by steep hills, and on the east by the abrupt mountains of the Barisan range, rising to altitudes of 3,000 to 5,000 feet. The probabilities of a clear sky seemed to be as good in Padang as anywhere on the main island. There appeared to be a slight advantage in favor of a station on one of the small low islands forming a chain five to ten miles off the coast, but as the sky was often thick with haze when not cloudy the advantage of such a location was not considered sufficient to counterbalance its disadvantages. It was, therefore, decided to remain in Padang, and a site for the station was chosen on the abandoned racecourse in the northern portion of the city. Its approximate position was—

Longitude $6^h\ 41^m\ 20^s$ East of Greenwich.
Latitude $0^\circ\ 56'$ South.

The programme of observations was entirely photographic, and was as follows:—

1st. Photographs of the prominences and inner corona with the 5-inch Clark lens of 40 feet focal length, after the method devised by Professor SCHAEBERLE.

2d. Photographs of the corona with the Floyd telescope of 5 inches aperture and 70 ± inches focal length.

3d. Photographs of the outer corona with the Pierson* (Dallmeyer) camera of 6 inches aperture and 32.6 inches focal length.

4th. Duplicate photographs of the region near the Sun for the detection of any small planets with orbits interior to that of *Mercury*. These negatives were to be secured with four telescopes of 3 inches aperture and 11 feet 4 inches focal length.

5th. One photograph of the spectrum of the corona, using one light prism, and having the slit east and west across the Sun's center.

6th. One photograph of the spectrum of the corona with a spectrograph similar to the preceding, but having the slit directed north and south, about 2′ east of the Sun's east limb. These two spectrographs were intended to record any Fraunhofer lines in the corona.

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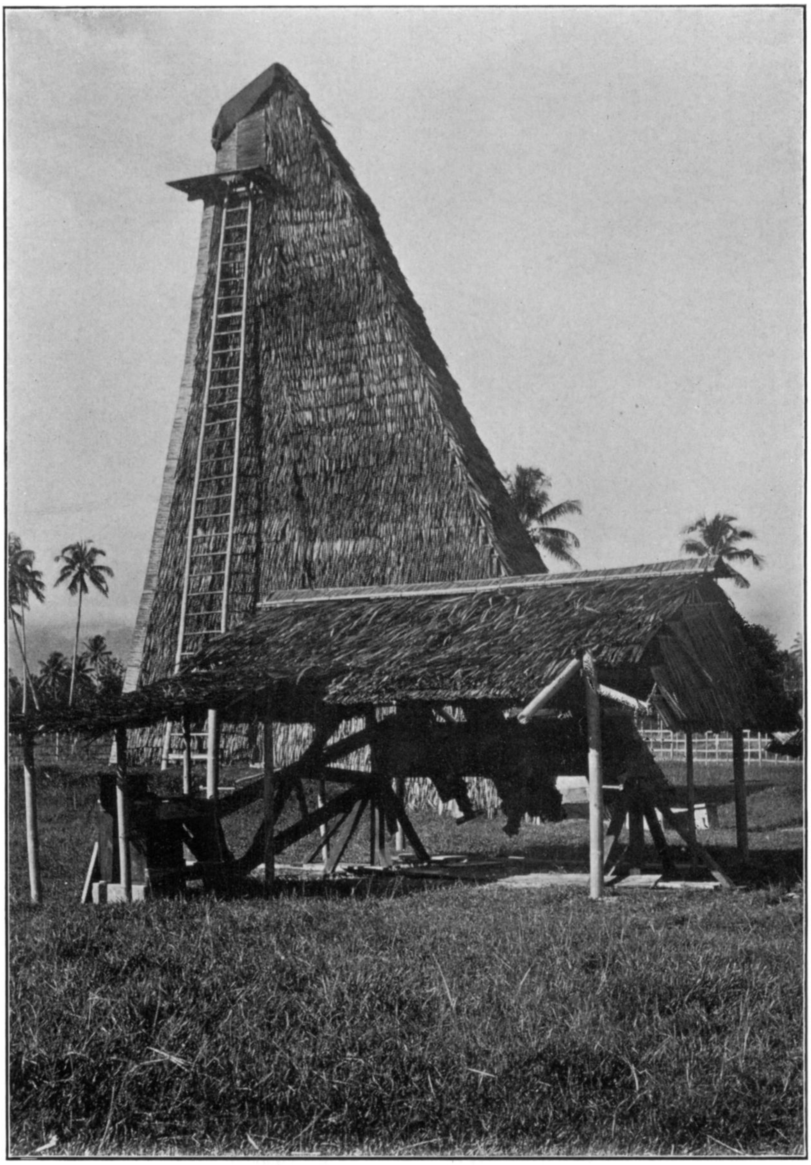
* This Dallmeyer portrait-lens belongs to Hon. W. M. PIERSON, of San Francisco, and has been very kindly loaned by him for a number of eclipse expeditions.

7th. Photographs of the corona with a camera of 20.75 inches focal length, having a double-image prism of one inch aperture placed in front of it. Photographs were to be secured of both images, the position-angle of the prism being changed during the eclipse so as to have its principal plane make angles of 0°, 22½°, 45°, 67½°, and 90°, respectively, with the Sun's equator. Such photographs should show polarization if it exists in a given plane to any considerable proportion.

A large shed of bamboo, covered with palm thatch (atap), was constructed first, serving as a work-shed and as a shelter for partly-mounted instruments. As showers were frequent and came with little or no warning, and as a protection against the sun also, shelters were constructed first and instruments mounted under them afterward. Many of the rains were very heavy — too heavy to be turned by canvas. As the residents of that moist country say, it rains in "strings," — and the "strings" are frequently almost ropes. After three days of one heavy storm it was noticed that the hollow bamboo fence-posts (just erected) surrounding the camp were overflowing; the deepest cavity in these was ten inches. How much more fell in the three days I do not know.

The tropics seem to be made of bamboo tied together with rattan and protected from the rains by "atap." It was only necessary to buy a small cartload or so of bamboo and atap and a bunch of rattan; out of these materials the expert Malay carpenters constructed everything. Sills, joists, rafters, all parts of framing, were of bamboo tied together with rattan. If a stake was wanted, the bamboo pile furnished it. If a fence was to be built, the same bamboo pile was resorted to, the posts were made of the full-sized thicker ends, the "boards" being long split sections passed through slots cut in the posts. The gate was of bamboo, even to the hinges and catch.

Only a slight elevation was available upon which to build the tower required to support the lens and tube of the 40-foot telescope, and as no excavation was possible, it was necessary to build a structure 36 feet high. Two towers were used after the plan adopted by Professor CAMPBELL at the Indian eclipse, and used also in Georgia. The inner tower was a mere skeleton of bamboo to support the lens. Around this was constructed another tower of bamboo, and covered with thatch to protect the lens-support from the wind. Upon this outer tower rested the frame of gas-pipe containing the canvas telescope-tube.



FORTY-FOOT CAMERA AND POLAR AXIS.

The ground was composed of sand and clay, saturated with water, and vibrations were easily communicated. The passage of a light cart along the street one hundred yards away caused such vibrations that sextant observations were impossible. It was feared that this unsteadiness of the ground would affect the images in the 40-foot telescope. In fact, the star-trails taken for focus did show irregularities, but as an examination of the Sun's image in transit and some experiments showed no vibration in the telescope, these irregularities could only be explained by atmospheric disturbances at night. It was noticed that the stars twinkled very markedly on all but a few nights.

Owing to the uncertainties of the climate, and the desirability of having shelter from the sun as well as from the rain, the roofs of the shelters for the intramercurial telescopes and the polar axis were hinged at the sides so that they could be opened or closed in a few seconds.

All of the smaller instruments, five in number, were mounted on one long polar axis, being driven by one clock. Although the exposures were of widely varying lengths, by using black cloths for exposing-caps and having all exposures, as far as possible, end at the same time, no difficulty whatever was experienced from jarring.

The tubes of the intramercurial planet telescopes, four in number, were made of sheet steel, five inches square at the objective end and increasing to the size of a 14 × 17 plate-holder. Each of the lenses was first mounted in a brass flange of good width. These were in turn secured by three sets of pushing and pulling screws to a brass casting screwed into the end of the steel tubes. This arrangement permitted of the final adjustment for focus and collimation with the same set of screws. The telescopes were mounted in two pairs, each pair consisting of two telescopes exactly parallel, thus permitting two simultaneous exposures of the same region of sky. The two pairs were so placed that their axes made an angle of 20° with each other, and were rigidly fastened together. This combination was then mounted on an auxiliary axis, which permitted the longer axes of the plates to be moved in the direction of the Sun's equator. As the 14 × 17 plates used covered a field of 5° 54′ by 7° 8′, two changes of position sufficed to cover a region 18° on either side of the Sun along his equator and nearly 6° in width. The most probable orbit of such a body would place it well within the region covered by such a series of photographs. The tubes and auxiliary axis were mounted in a large wooden box, and this in turn was mounted equatorially and driven by a clock operating at the end of a sector of ten feet radius. With the exception of the steel tubes, the mounting was constructed at the Lick Observatory by our skilled workmen. Though necessarily cumbersome, it performed admirably, being very rigid and coming to rest almost immediately after disturbance.

The performance of the single achromatic lenses * used for this work was very satisfactory. Good images were secured over a 14 × 17 plate with the exception of the corners, and even here the distortion was not serious.

All the instruments were mounted and practically in adjustment by May 12th. The intervening time was devoted to drilling the assistants, to checking the adjustments of the many instruments, and to arranging the final details.

A dark-room had been improvised, for night use only, in a small native bamboo house on the grounds. Preliminary experiments in photographic work had been made in the photographic department of the "Staatsspoorweg," which had been placed at our disposal by Mr. DELPRAT, Chief Executive of these government railways. The day temperatures generally ranged from 85° to 90° F., the air being almost saturated. The night temperatures were but little below 80°, with a heavy precipitation of dew. In continued rainy or cloudy weather the temperature fell to from 70° to 75° during the night and early morning. Photographic manipulations under such conditions were not easy, but with some changes in the formula, and by a liberal use of ice and alum, good results were secured with *fresh* plates. Plates exposed for any considerable time to the action of the atmosphere deteriorated rapidly, one of the most marked changes being a great loss of sensitiveness. It is not sufficient that the pasteboard boxes containing the plates shall be sealed; the only real protection is to have them hermetically sealed in metal boxes. The plates for eclipse work had been sent in two lots, one containing those needed for the focusing of the instruments, the

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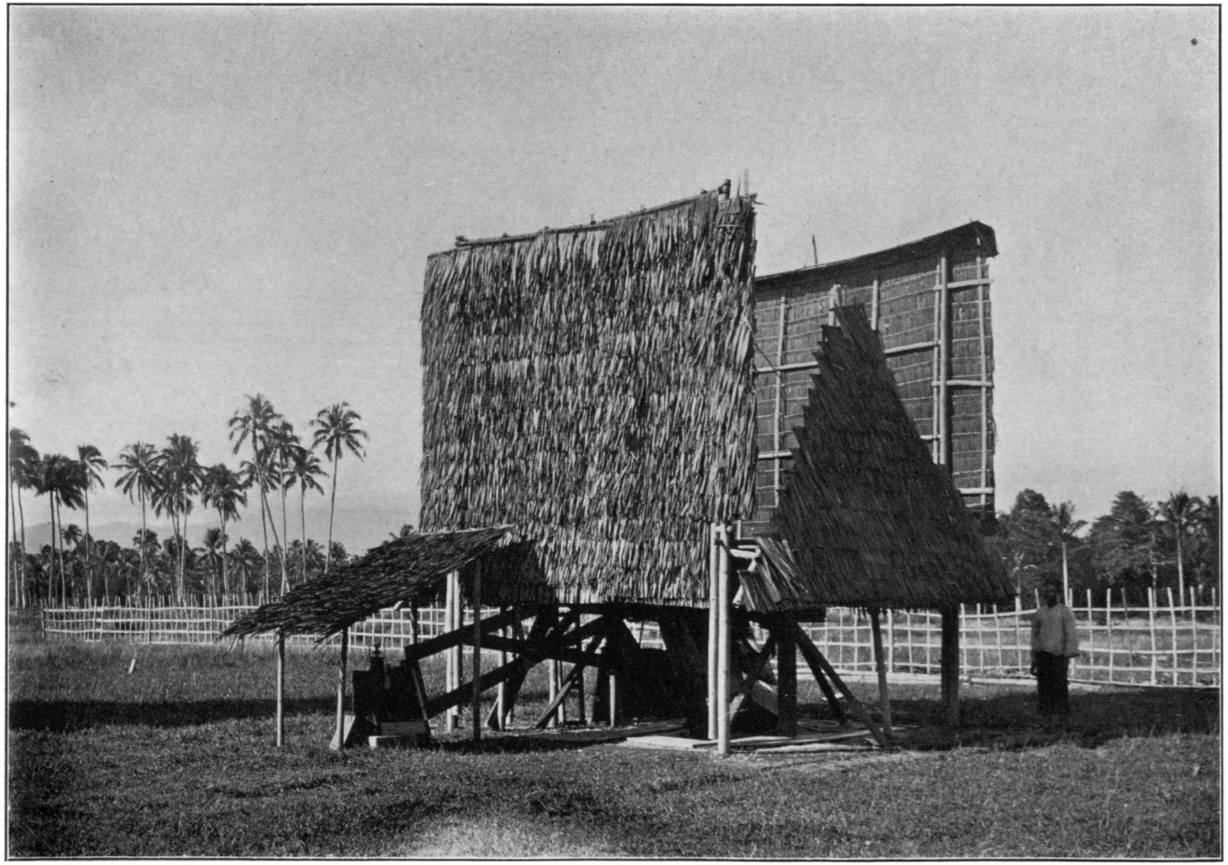
* These lenses were designed by Professor W. H. PICKERING, and used by him at the 1900 eclipse. Two of those used in Sumatra were kindly loaned by Professor E. C. PICKERING, Director of Harvard College Observatory. The other two were of the same design, made by ALVAN CLARK & SONS for the Lick Observatory, through the kindness of Professor PICKERING.



INTRAMERCURIAL TELESCOPES (SHELTER OPEN).

other lot for use on eclipse-day. Each lot was soldered up tightly in a tin box, that containing the plates for the eclipse not being opened until the night before, when all the holders were loaded. Plates which I carried along in my trunk, for viewing purposes, had so deteriorated, even before reaching Padang, as to be useless.

Offers of assistance in making the observations had been tendered liberally as soon as it was known that such help would be needed. Fifteen persons were invited to assist. Rehearsals of the programme to be carried out at the eclipse were begun four days before. In this way all gained familiarity with the necessary motions, and the programme was carried out with entire confidence. The observers and their stations were as follows:—

Time was counted at the chronometer and the necessary orders given (all in Dutch) by Mr. DELPRAT.

Forty-foot telescope: Messrs. R. H. CURTISS and F. BOUMAN.

Intramercurial telescopes: The exposures were made by Mr. NIEUWENHUYS. The plates were changed by Messrs. CLETON, GULDENAAR, D'HANENS, and PERRINE, the latter making the necessary changes of position of the telescopes.

Floyd telescope: The exposures were made by 1st Lieutenant P. L. DE GAAY FORTMAN, and the plates changed by 2d Lieutenant WARNSINCK.

Pierson (Dallmeyer) camera: The exposures were made by Mr. VON DER STRAETEN, and the plates changed by Mr. VON LEEUWEN BOONKAMP.

Radial slit spectrograph: This instrument was operated by Mrs. DE GAAY FORTMAN.

Tangential slit spectrograph: This spectrograph was operated by Mr. JUNIUS.

Polarigraph: The exposures were made by 2d Lieutenant SIEBURGH, and the plates changed by Mr. J. KEMPENS.

Shadow bands were observed by Mr. LAGERWEY.

The day before the eclipse had been one of clouds and rain, as was the day following. Eclipse-day dawned not altogether auspiciously, but with some promise. Light clouds covered the entire sky, but seemed to be growing thinner, and occasionally glimpses of blue sky could be seen. The Sun's disc was almost entirely free from clouds at first contact, although the rest of the sky was generally covered. The sky did not improve, however, as the eclipse progressed. At no time during totality was the sky about the Sun clear, light cirrus clouds and haze covering the entire sky, with the exception of a perfectly clear area near the northern horizon.

During the morning there had been some wind from the north, west, and south, but as the obscuration increased it began to die down. Canvas wind-screens had been placed about the polar axis and the intramercurial telescopes during the morning, but were not needed, as there was a perfect calm during totality. This dying-out of the wind I have noticed also at the two previous eclipses which I have observed.

The usual phenomena of light changes and cooling of the atmosphere were observed. No measures of light intensity were made, but a table of logarithms was placed where the light of the corona and surrounding sky shone fairly upon it and at mid-eclipse it was necessary to look closely to distinguish the figures. After the middle of totality the increase of light was quite marked, due partly, in all probability, to the increasing cloudiness. During the afternoon the sky overhead and to the west became entirely clear.

The entire programme was carried through successfully, although at that time there was scant hope of many results of value. No attempt was made to develop any plates in daytime, but during the following four nights the work was completed. It was an agreeable surprise to find that negatives of value had been secured with all the instruments.

Following is a list of the negatives secured, with the principal data relating to them, and a short description of the result on each:—

LIST OF NEGATIVES.

40-FOOT CAMERA.

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
1	8 x 10	Carbutt B	1/28	Good.
2	14 x 17	Seed 27	1	Good. Detail off E. limb well shown.
3	14 x 17	Seed 27	2	Good. Detail off E. limb well shown.
4	14 x 17	Seed 27	4	Good. Corona to 15′.
5	14 x 17	Seed 27	16	Good. Corona to 15′.
6	18 x 22	Seed 27	40	Good. Corona to 20′.
7	18 x 22	Seed 27	150	Good. E. streamer to fully 1⅓ diameters.
8	14 x 17	Seed 27	4	Good. But little corona.
9	14 x 17	Seed 27	25	Good. About the same extension as No. 3.
10	14 x 17	Seed 27	8	Good. Much less than Nos. 3 and 4.
11	14 x 17	Seed 27	1	Good.
12	8 x 10	Carbutt B	½	First flashes of returning sunlight.

FLOYD 70-INCH CAMERA.

1	5x7	Seed 27	½	Good. Streamers to 10′.
2	5x7	Seed 27	2	Good. Eastern extension to one diameter.
3	5x7	Seed 27	8	Good.
4	5x7	Seed 27	4	Good. Streamers to 25′.
5	5x7	Carbutt B	60	Good. Streamers to over a diameter.
6	5x7	Seed 27	20	Good. Extensions only 15′.
7	5x7	Seed 27	2	Good. Extensions only 5′.
8	5x7	Seed 27	½	Good.

PIERSON (DALLMEYER).

1	8x10	Seed 27	½	Eastern streamers to one diameter.
2	8x10	Seed 27	2	Eastern streamers to one diameter.
3	8x10	Seed 27	8	Eastern streamers to one diameter.
4	8x10	Carbutt B	30	Over-exposed.
5	8x10	Seed 27	4	Slide not drawn.
6	8x10	Carbutt B	60	Over-exposed. Eastern streamer to 1¼ diameters.
7	8x10	Seed 27	20	Slide not drawn.
8	8x10	Seed 27	10	Corona to 20′.
9	8x10	Seed 27	2	Caught by returning sunlight.
10	8x10	Seed 27	½	Not exposed.

INTRAMERCURIAL.

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
A 1	14x17	Seed 27	90^s	28 stars. Faintest = 8.8 visual magnitude.
B 1	14x17	Seed 27	90	
C 1	14x17	Seed 27	90	37 stars. Faintest = 8.6 visual magnitude.
D 1	14x17	Seed 27	90	
A 2	14x17	Seed 27	90	27 stars. Faintest = 8.8 visual magnitude.
B 2	14x17	Seed 27	90	
C 2	14x17	Seed 27	90	No star images.
D 2	14x17	Seed 27	90	
A 3	14x17	Seed 27	75	No star images. Inner corona and *Mercury* and *Venus* are distinct.
B 3	14x17	Seed 27	75	
C 3	14x17	Seed 27	75	No star images.
D 3	14x17	Seed 27	75	

SPECTROGRAPH I (SLIT TANGENTIAL).

No.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
1	2⅛x3¼	Cramer Crown	320^s	Good.

SPECTROGRAPH II (SLIT RADIAL).

1	2⅛x3¼	Cramer Crown	320^s	Good.

POLARIGRAPH.

No.	Setting.	Size of Plate.	Kind of Plate.	Exposure.	REMARKS.
1	0°	3¼ x 4¼	Cramer Crown	1^s	Negative good.
2	0	3¼ x 4¼	Cramer Crown	10	Slide not drawn.
3	22½	3¼ x 4¼	Cramer Crown	1	Negative good.
4	22½	3¼ x 4¼	Cramer Crown	10	Negative good.
5	45	3¼ x 4¼	Cramer Crown	1	Negative good.
6	45	3¼ x 4¼	Cramer Crown	10	Negative good.
7	67½	3¼ x 4¼	Cramer Crown	1	Negative good.
8	67½	3¼ x 4¼	Cramer Crown	10	Negative good.
9	90	3¼ x 4¼	Cramer Crown	1	Negative good.
10	90	3¼ x 4¼	Cramer Crown	10	Negative good.

The negatives secured with the 40-foot telescope show the extreme inner corona and the prominences as well, probably, as if the sky had been clear. The two long exposures of 40 and 150 seconds, respectively, show detail in the middle corona, and the latter shows the streamers of the eastern equatorial extension to one and one-third diameters from the limb. Some of the detail at this distance is lost, however. A number of small prominences, exhibiting considerable detail, are shown on the east limb. One of these prominences, in position-angle 115°, is covered by a series of marked "hoods," or envelopes. There are other structures of this nature, but much less pronounced.

One of the most interesting features of the corona was an area in the northeastern quadrant where clouds of coronal matter were piled up as if by an explosion on the Sun's surface. That it is true coronal matter is indicated by the tangential spectrograph which had its slit across this region. The disturbed area appeared to have its origin in position-angle 65°, near a small compact prominence, and masses of matter are shown radiating from it in almost all directions. A long thread-like prominence to the south appears to emanate from this same region. The whole area resembles the condensations seen in photographs of the *Orion* and other irregular nebulæ. All the appearances point strongly to a direct connection with an eruption in some part of the Sun's surface, thus linking the corona closely with other solar phenomena, all requiring a single explanation. So far as I am aware, no such appearance as this in the corona proper has been observed at any previous eclipse.

The inner corona is well shown on the smaller-scale negatives obtained with the FLOYD telescope, but beyond one and one-quarter diameters the corona was so faint as to be lost in the clouds and haze. This is also the case with the negatives obtained with the PIERSON camera; in fact, with this instrument the long exposures recorded the images of the clouds. Owing to the inadequacy of the half-tone process to bring out fine details, illustrations of the corona are omitted for the present.

The clouds interfered most with the intramercurial planet search. The plates taken of three regions out of the six show 92 stars, the faintest being from 8.6 to 8.8 magnitude, but so far no star-images have been found on the plates of the other three regions. A careful preliminary examination of the plates was made at the station in Sumatra, but no suspicious object detected. A thorough search of all the plates will be made later, and it is hoped that some stars may be found on all of the plates, thus enabling some conclusion to be drawn as to the maximum brightness which any such body or bodies can have.

The earlier exposures with the polarigraph show the equatorial extensions of the corona to one diameter from the limb; toward the end of totality only about one quarter of a diameter is shown, owing to the increased cloudiness. A large percentage of polarization is indicated in the light of the corona beyond 10′ from the limb, and the later exposures point to a small percentage of polarization in the inner corona also. This is true of all position-angles, including the regions containing the polar streamers. The double-image prism used in this instrument separated the two images about 1¼ degrees. These were extremely convenient for comparison with each other, and the method of detecting polarization effects was practically a differential one.

The two spectrographs (as well as the polarigraph) were designed and prepared for use by Director CAMPBELL and Assistant Astronomer W. H. WRIGHT. The results obtained show both instruments to be very efficient for the purpose of recording dark lines in the spectrum of the corona. In a clear sky the spectrum of the inner corona would have been over-exposed.

Radial Slit Spectrograph.—The slit of this instrument was placed east and west across the Sun's center. The negative covers the region from λ 490 to λ 360 ±, the spectrum extending on either side of the Moon's disc to over a diameter. The image of a prominence on the east limb of the Sun covered the slit, producing very bright over-exposed *H* and *K* calcium lines, as well as the other characteristic prominence lines. On either side of the Moon's disc is a band of continuous spectrum about 8′ in width without any trace whatever of dark lines. Outside of this band at least 35 Fraunhofer lines can be counted between $H\beta$ and H, extending out to the limits of the spectrum. Beyond $H\beta$ and H, in either direction, there is but little trace of the spectrum of the outer corona. A longer exposure would doubtless have shown all the Fraunhofer lines observable with the slit-width and dispersion used. Bright H and K lines of marked strength extend entirely across the Moon's disc, and to a distance of 40′ east of the Sun's limb, but show only feebly on the west side of the Sun. They are symmetrical with reference to the image of a prominence on the east limb, indicating a diffusion in our atmosphere of calcium radiations from this and other neighboring prominences. Comparisons with a sky spectrogram secured with the same instrument show that the coronal and sky spectra are sensibly the same in the blue and violet regions.

Tangential Slit Spectrograph.— The slit was placed north and south across the corona about 2′ east of the Sun's east limb. The negative shows practically the same range of spectrum as the preceding one, with a width of rather over a solar diameter.

The H and K lines are bright and quite strong, the latter having the greater intensity. No doubt these are due to calcium radiations diffused in our atmosphere. No other bright lines are to be seen. Although the continuous spectrum is strong, none of the details are obliterated. Several stronger bands extend longitudinally through the spectrum, which are due in all probability to the brighter condensations in the corona proper. Many Fraunhofer lines are visible, especially between $H\gamma$ and K, and can be traced across the full width of the spectrum. They are less distinct where they cross the dark belts mentioned above. The disturbed area of the corona, already referred to, fell across the slit of this instrument. This spectrogram was also compared with a sky spectrogram, as in the previous case, and the same agreement of the lines was noted.

A consideration of all the facts shows that the clouds have not affected these results nor their interpretation.

Professor CAMPBELL has examined these spectrograms and confirms the above results.

It should be noted that the spectroscopic observations made at the India eclipse of 1898 by Professor CAMPBELL also showed no trace of dark lines in the inner corona. These spectrograms extended only to a distance of 2′.5 from the limb, being obtained with high dispersion.

The preceding spectroscopic and polariscopic observations seem to point to a very definite explanation of the general constitution of the Sun's corona. Both methods of investigation show that the light of the outer corona is in great measure reflected sunlight, whereas the spectrograph shows the light from the inner corona to emanate principally from incandescent matter. These facts, taken in connection with the varying appearance of the corona, suggest as the most probable explanation that very finely divided matter is ejected from the surface of the Sun with great velocity, giving rise to the streamers and extensions observed. This matter may or may not be solid when it first leaves the Sun, but observation indicates that it is incandescent, and probably largely solid, when it first becomes visible above the layer of chromosphere. While in a state of incandescence its inherent light would in all probability be so great as to mask the light which must be reflected from the solar surface; but a point would be reached in its outward journey where it would become cool enough for the reflected light to become observable. Actual radial motion has not been observed in true coronal matter, but appearances point far more strongly to great movement than to a state of comparative rest.

The well-known bright lines observed on many occasions in the corona indicate, also, an irregular but comparatively thin gaseous envelope about the Sun. The quantity of light contained in the bright-line spectrum, however, is very small in comparison with that composing the continuous spectrum; and it is probable that the gaseous envelope does not appreciably affect the ordinary photographs of the corona.

The explanation suggested above, deduced through a different train of reasoning, from an entirely distinct set of facts, is in accord with the conclusion reached by Professor SCHAEBERLE from a study of the forms of the coronal streamers shown in his large scale photographs of the 1893 eclipse, that these streamers are composed of matter ejected from the Sun with great velocity.

The sky was unfavorable for Shadow-Band observations. Mr. LAGERWEY, however, detected faint bands at the beginning of the eclipse. These bands had wavy outlines at first, becoming almost straight toward the end of their apparition. The direction of the wave front was north 60° east and south 60° west, the waves moving in a direction at right angles to the wave front.

TIMES OF CONTACTS.

The first three contacts were observed by me, as follows:—

	h.	m.	s.	
I	22	45	30.9	mean time of station.
II	0	18	52.3	
III	0	25	1.3 ± 1^s	

Observed duration of totality, $6^m\,9^s.0$.

The following are the times of the contacts for the station, computed from the data given in the American Ephemeris:—

	d.	h.	m.	s.	
Beginning of eclipse,	May 17	22	45	16.1	mean time of station.
Beginning of totality,	May 18	0	18	49.9	
End of totality, . .	May 18	0	24	56.8	
End of eclipse, . .	May 18	1	57	25.5	

Computed duration of totality, $6^m\,6^s.9$.

Contact I was observed with the sextant, and is probably 2^s or 3^s later than geometrical contact. Contacts II and III were observed without optical aid. Contacts I and II were timed directly from the chronometer; contact III by means of the counts of the timekeeper, and is subject to a possible uncertainty of a second. As soon as possible after totality the counts were compared directly with the chronometer. The corrections to the chronometer were determined from sextant observations of the Sun.

The time observation secured after the eclipse indicated a considerable change of rate of the chronometer subsequent to the observation of the same morning. About ten minutes before the beginning of totality the chronometer was removed from the shelter, where it had remained undisturbed on a pier, in order to permit the timekeeper to have a view of the eclipse, and replaced in its original position shortly after totality. In determining the chronometer corrections at the time of the contacts it has been assumed that the change of rate occurred with the change of position of the chronometer.

THE GREAT SOUTHERN COMET.

On May 4th a telegram was received from Professor SKINNER announcing that a brilliant comet had been observed by Mr. DINWIDDIE at Solok, in the western sky, just after sunset of the previous evening. The evening of May 4th was cloudy at Padang, but the evening of May 5th was clear, and the comet was seen low in the west against a very bright sky. Sextant observations were secured of its position, using the nearest available stars. As the sky darkened it became a very conspicuous object. It had a brilliant nucleus, and a tail 6° to 8° in length. The Pierson camera was mounted on the following day and directed to the place of the comet. Owing to the brightness of the sky and to the lack of means for following the comet, only short exposures were attempted. Four negatives were secured on May 6th, as follows:—

	Duration of exposure.	Length of tail.
No. 2_2	1^m	3°
4_2	3	3½
1_4	7	4
1	$0^m\ 30^s$	

The last plate contained no image, owing to the haze and proximity of the comet to the horizon.

The principal tail is composed of two slightly curved and nearly parallel streamers. The second and third negatives show a very faint streamer to the south, making an angle of 35° with the axis of the principal tail.

Clouds near the western horizon prevented any further observations or photographs, although the instruments were left in readiness until it became necessary to adjust them for the eclipse.

Mr. RALPH H. CURTISS, formerly assistant in the Students' Observatory, University of California, was appointed assistant in the Lick Observatory from February 15th, and accompanied the expedition, helping throughout in the work of preparing the station and in the observations.

A most cordial welcome was extended to eclipse observers by the officials and citizens of Padang, and I am largely indebted to them for the results secured. Especial thanks are due to His Excellency, Governor JOEKES for introductions to heads of departments and for his interest in the welfare and safety of the expedition at all times; to Kolonel H. F. C. VAN BIJLEVELT, commander of the army, who detailed a number of his officers to take part in the observations; to Major MULLER, of the general staff, N. I. Army, for advice as to the meteorological conditions and the choice of a station, as well as for many practical suggestions; to Assistant Resident HARTOGH HEISS, head of the police department of Padang, who not only made arrangements for the location for the station and obtained watchmen, but in his official capacity had the safety of the camp as his immediate care. On the day of the eclipse a body of twenty special policemen, with an equal number of employees from the railway, formed a cordon about the camp.

Mr. TH. F. A. DELPRAT, as chief executive of the railways, not only furnished free transportation for observers and apparatus over the railroads, but placed a fully equipped photographic dark-room and the facilities of the very extensive shops and stores at our disposal, detailed skilled workmen for specially important work, and at all times was ready to give advice and cordial help.

Mr. F. BOUMAN, chief of the construction department of the railways, with a wide acquaintance of the natives, practically superintended the construction of all the shelters and buildings required. We were thus relieved of many of the trials and extortions incident to dealings with the Malays by foreigners.

Mr. C. G. VETH, United States Consul at Padang, extended many courtesies to the eclipse observers, and was ready at all times to aid them. After the eclipse and just before the departure of the U. S. S. "General Alava," with the U. S. Government party of astronomers aboard, a banquet was given by Consul VETH in the ship's honor, to which all the astronomers were invited. It was a great surprise to hear the English language so generally spoken. A most enjoyable time and one long to be remembered was the result.

Social courtesies were freely extended by the residents of Padang, and served to enliven our busy sojourn there.

Those who took part in the work of observation were: Heer TH. F. A. DELPRAT, 1st Leutenant der genie P. L. DE GAAY FORTMAN, 2d Leutenant der Infanterie W. H. WARNSINCK, 2d Leutenant der Infanterie E. SIEBURGH, Mevrouw DE GAAY FORTMAN, Heer J. KEMPENS, Heer F. BOUMAN, Heer VAN LEEUWEN BOONKAMP, Heer VON DER STRAETEN, Heer JUNIUS, Heer CLETON, Heer NIEUWENHUYS, Heer GULDENAAR, Heer D'HANENS, Heer LAGERWEY.

The greatest enthusiasm was manifested by all in the preliminary rehearsals as well as in the observations on eclipse day.

Favors were shown to the expedition in all possible ways, from Mt. Hamilton to Padang, every one being not only willing but anxious to aid. Among these especial mention should be made of Mr. ROBERT BRUCE, of the firm of Balfour, Guthrie &

Co., of San Francisco; the Toyo Kisen Kaisha; the Occidental and Oriental Steamship Company; the Pacific Mail Steamship Company; the officers of the S. S. "Nippon Maru"; Mr. AUBREY FAIR, of Hong Kong; Mr. A. I. ROSS and Mr. T. SCOTT of the firm of GUTHRIE & Co., Singapore; the agents and officers of the "Koninklijke Paketvaart-Maatschappij" and "Stoomvaart Maatschappij Nederland"; the representatives of the firm of J. DAENDELS & Co., in Singapore, Batavia, and Padang; the officers of the Hong Kong and Shanghai Bank, in San Francisco and Batavia, and the Java Bank, in Padang.

The natives were much aroused at the advent of so many astronomers, and the preparations for an event in which they had at first no faith whatever. Some of the keenest of their religious leaders, however, saw an opportunity, and shortly before the eclipse began to prophesy and to take much credit to themselves. The advent of the comet a fortnight before the eclipse and an epidemic about the same time in the native Kampong, from which many died, excited the more superstitious ones, and a rumor was brought to me that our camp was to be demolished. Whether we were in any particular danger or not will probably never be known, but there was anxiety in the police department until all was over. Our stay ended without an interruption and without any loss or damage to the instruments.

At the suggestion of Professor TODD, the various telegraph companies offered to transmit a message from Mauritius to the observers at Padang, giving them an hour or more in advance, the benefit of observations at the former point. A letter was sent to Padang, addressed to eclipse observers, by General Manager TAYLOR of the Eastern Extension Australasia and China Telegraph Company, Limited, at Singapore, notifying them of the arrangements made by the different lines for the transmission of this message. This letter was delivered by the postal authorities to me, and I at once notified all observers in Sumatra, within my knowledge, of its contents. Arrangements were made with the telegraph office in Padang for the prompt distribution of this message, which, however, failed to arrive.

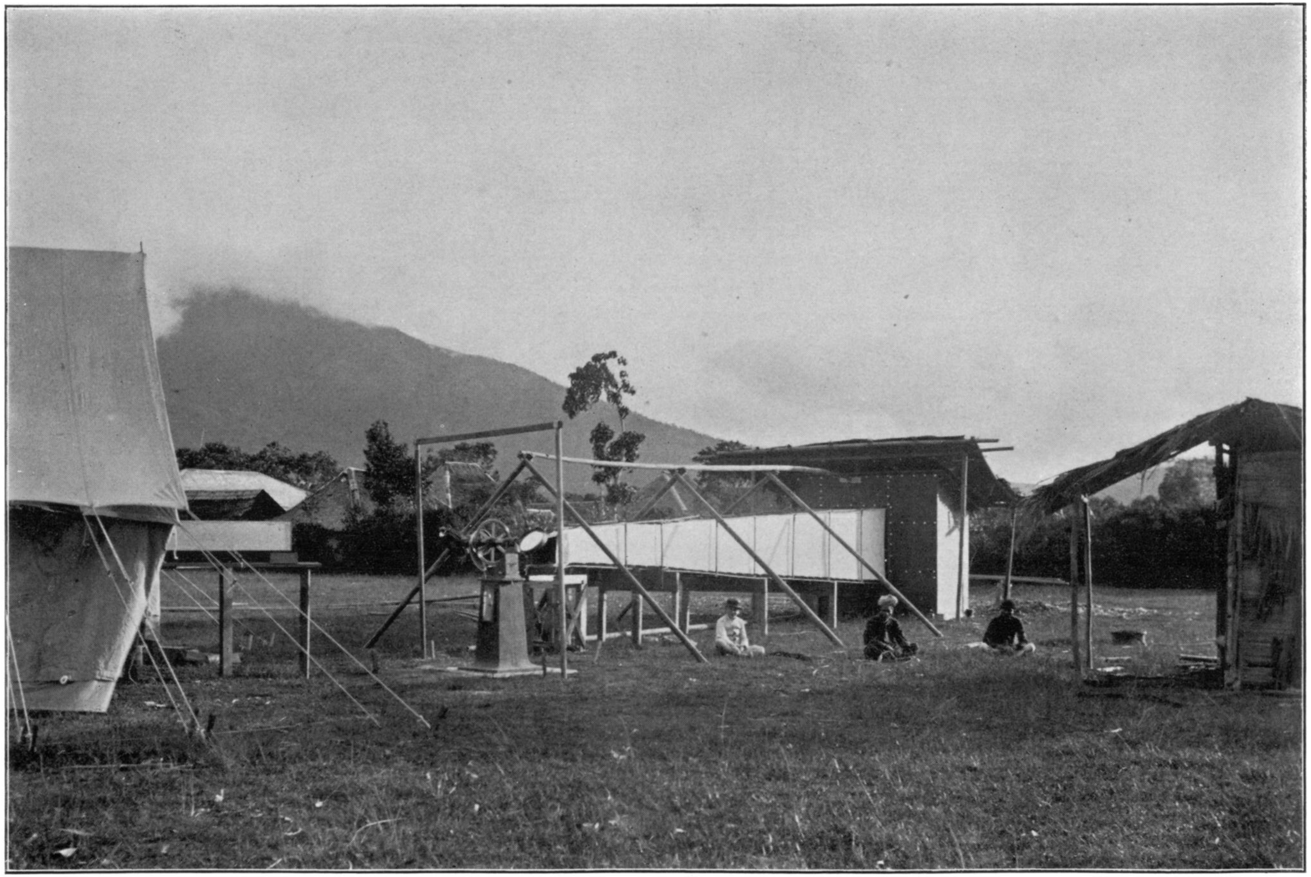
After the eclipse was over, and the instruments all packed for shipment, a few days were spent in the interior of this very interesting but little-known island, visiting the peculiar native markets, climbing one of the active volcanoes, and seeing the Malays at home.

The lowlands of these tropical islands are hot, humid, and uncomfortable, but the higher lands have a most delightful temperature. At altitudes of 3,000 to 4,000 feet the temperature was that of a perfect early summer day of the temperate zones, very warm at midday, if clear, but pleasant at night,— cool enough for a light bed-cover, but without any chilling winds. The humidity at all altitudes is very near the saturation point, which, together with the warmth, causes a most luxuriant vegetation everywhere, a dense, impenetrable jungle where not kept down by constant work. Even the volcanic peaks which have been in eruption within a generation are again clothed with dense forests, covering all the scars. The rugged mountains, the towering volcanoes, some of them still active, the rice-paddies, the picturesque habitations of the natives, and the natives themselves, offer sights and adventures of surpassing interest, for this is indeed a world *contra* to all temperate climes.

Both going and returning we passed Krakatoa, in the Straits of Sunda, and it was not without a thrill that I looked upon that relic of a convulsion of nature which has perhaps no equal in history. Its appearance is proof enough of the tales of that outburst in 1883, when a superb volcanic cone half a mile in height was split asunder and one half lost in the sea; when all the contiguous islands and the near-by coasts of Java and Sumatra were devastated, their inhabitants and wealth utterly destroyed, and even the very face of nature changed; when ships were carried miles inland by the tidal wave over hills as high as their masts,— a convulsion which was thought to be the "crack of doom" by millions, and which was in reality such to tens of thousands. In April this giant was without any sign of life, but early in June smoke in considerable volumes could be seen rising from the almost perpendicular north face, the scar of the outburst of eighteen years ago.

It was a great pleasure to renew a number of acquaintances in Sumatra, and to meet for the first time many prominent astronomers from all parts of the world.

MT. HAMILTON, CALIFORNIA, 1901, November 11.



THE CAMP AT FORT DE KOCK.